Blast Design of Cold Formed Steel Connections

Technical Note

Strength Tables for Special Seismic and Blast Design of Cold Formed Steel Connections

By: Kurtis Kennedy, E.I.T.
Nabil A. Rahman, Ph.D., P.E.

The Steel Network, Inc.
2012-A T.W. Alexander Drive
P.O. Box 13887
Durham, NC 27709
Phone: (888)474-4876
www.steelnetwork.com

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STRENGTH TABLES FOR SPECIAL SEISMIC AND BLAST DESIGN OF COLD FORMED STEEL CONNECTIONS

Kurtis Kennedy, P.E., and Nabil A. Rahman, Ph.D., P.E.

Introduction

Various specifications and design standards allow the use of nominal strength of material when calculating resistance values of components for special blast or seismic design. Beyond the use of nominal strength, some design codes allow the use of an increased nominal strength or an increased expected strength. A Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF) can be applied to nominal and expected strength, respectively, to attain greater material strength of components for special design purposes and when using dynamic analysis. The Steel Network has developed LRFD design strength, nominal strength and ultimate strength tables for each connector manufactured which can be used in special seismic and blast design and are compatible with the Static and Dynamic Strength Increase factors. This technical note provides background on the development of TSN connectors' strength and how to use it for seismic and blast design per various codes and standards in the US.

Seismic Design

Special seismic design requirements are mandated in AISI S213 section C1.1 "Seismic Requirements", which are applicable to the design of cold formed steel shear walls or systems using diagonal strap bracing that resists wind, seismic, or other in-plane lateral loads. Section C1.1 directs the designer to the "Special Seismic Requirements" section, Section C5, if the design is in the United States or Mexico and the Response Modification coefficient, R, is greater than 3.

Section C5 "Special Seismic Requirements" is referenced and contains the provisions allowing nominal strength of materials to be used in the design of members and/or connections. Section C5.1 "Shear Walls" and Section C5.2 "Diagonal Strap Bracing" presents the provisions for design of connections, chord studs, anchorage, and foundations when using a shear wall or diagonal strap bracing lateral force resistance systems. Section C5.2.2.2 presents provisions that allow the nominal strength to be used for design of connections in the load path of diagonal strap bracing. This section states:

"All members in the load path and uplift and shear anchorage thereto from the diagonal strap bracing member to the foundation shall have the ***nominal strength*** *to resist the expected yield strength $A_gR_yF_y$, of the diagonal strap bracing member(s), except the* ***nominal strength*** *need not exceed the following, as applicable:*

(a) In the United States and Mexico: Amplified seismic load.
(b) In Canada: Maximum anticipated seismic loads calculated with R_dR_o= 1.0."

The load to design for is the expected strength of the diagonal strap bracing, but not to exceed the amplified seismic load.

Blast Design

UFC 4-010-01 Section B-3 outlines the design of window and skylight systems under extreme pressure loading such as a blast. Provisions are given for a static or dynamic method of design for window and skylight opening framing and connections. Section B-3.1 "Standard 10. Windows and Skylights" provides guidance on not reducing the nominal strength with a strength reduction factor for flexural mode. The code states:

"Use strength design with load factors of 1.0 and ***strength reduction factors*** *of 1.0 for all methods of analysis referenced herein \1\ for flexure and use typical strength reduction factors for other modes of failure."*

The UFC design code provides an alternative design method utilizing the dynamic material properties of the window glazing, framing members, connections, and supporting structural elements. Section B-3.1.1 "Dynamic Analysis" states:

"Any of the glazing, framing members, connections, and supporting structural elements may be designed using ***dynamic*** *analysis to prove the window or skylight system will provide performance equivalent to or better than the hazard rating associated with the applicable level of protection as indicated in Table 2-1... The design loading for a* ***dynamic*** *analysis will be the appropriate pressure and impulse from the applicable explosive weight at the actual standoff distance at which the window is sited. The design loading will be applied over the area tributary to the element being analyzed."*

The dynamic method of analysis and design of framing members incorporates strength increase factors that enhance the nominal and expected strength of materials. A Static Increase Factor (SIF) or Average Strength Factor (ASF) can be applied to the nominal strength of a material, while a Dynamic Increase Factor (DIF) can be applied to the expected strength of a material.

Documents such as the UFC 3-340-02, the ASCE Publication "Design of Blast-Resistant Buildings in Petrochemical Facilities", and the ASCE 59-11 Standard describe Static and Dynamic Increase Factors and the uses of each. Since the nominal strength is typically taken as the lower bound minimum yield strength of the material, the Static Increase Factor (SIF) or Average Strength Factor (ASF) are applied to the nominal strength to account for higher yield strength of installed components than minimum specified yield strength values. The resultant value is the "expected strength". Beyond the use of this expected strength level, ASCE and the UFC code states that the Dynamic Increase Factor (DIF) is to be applied to the expected strength to account for strain rate effects from a rapid blast loading to achieve greater dynamic strengths. Table 1 shows suggested increase factors to be used for cold-formed steel design as recommended by two different ASCE publications and the DoD UFC 3-340-02.

Table 1 - Static and Dynamic Increase Factors for Cold-Formed Steel

	Static Increase Factor (SIF) or Average Strength Factor (ASF)	Dynamic Increase Factor (DIF)	
		Bending/ Shear	Tension/ Compression
ASCE/SEI 59-11 (2011)	1.1	1.1	1.1
ASCE Design of Blast-Resistant Buildings in Petrochemical Facilities (2010)	1.21	1.1	1.1
UFC 3-340-02 (2014)	1.21	1.1	1.1

In reference to the AISI S100-12 Specifications and the development of the nominal strength tables, it should be noted that LRFD design strength is typically determined as the nominal strength multiplied by the appropriate resistance factor (φ). Chapter F of the AISI Specification permits the calculation of LRFD design strength based on the ultimate strength of a specimen tested according to the provisions given within. This ultimate strength value is then multiplied by a smaller resistance factor than what is given in the main specification. **Figure 1** is a diagram depicting the various levels of strength and the relationship between LRFD design strength, nominal strength, expected strength, ultimate strength, and dynamic strength.

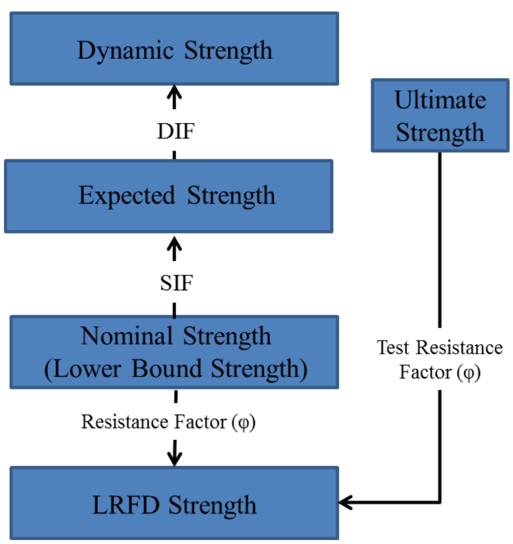

Figure 1 - Strength Relationship Diagram

Strength Tables

The Steel Network has developed the following tables to present the LRFD design strength, nominal strength, and ultimate strength for all clip connectors manufactured. The ultimate and LRFD values for each clip are calculated according to the test method specified in AISI S100-12, Chapter F. The nominal strength is calculated as the LRFD strength divided by an average resistance factor of 0.9. Clip connectors or load directions marked with an (*) have their LRFD, nominal, and ultimate strength values all calculated using AISI S100-12 provisions.

MasterClip™ Series

Connector (Application)	Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
VLB600 (Vertical Deflection)	F1	364	405	661
	F2	2,509	2,788	4,245
VLB600 (Rigid Connection)	F1	1,481	1,646	2,506
	F2	3,297	3,664	5,579
	F3	2,869	3,188	4,855

Notes:
Strength values provided are those of the clip only (One clip). Attachment to stud framing and to structure must be evaluated independently.
Nominal Strength is calculated as LRFD Strength divided by an average resistance factor of 0.9.
Ultimate Strength is the average maximum load obtained from tests.
When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).

VertiClip® Series

Connector	Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
SL362	F1	397	441	721
	F2	1,696	1,885	2,680
SL400	F1	318	353	600
	F2	1,817	2,019	3,074
SL600	F1	588	653	1,068
	F2	2,691	2,990	4,251
SL800	F1	579	643	1052
	F2	2,994	3,327	4,730
SL1000	F1	664	738	1,206
	F2	2,521	2,801	4,266
SL1200	F1	611	679	1,110
	F2	2,863	3,182	4,845
SLD150	F2	82	91	139
SLD250	F2	254	282	430
SLD362/400	F2	575	639	973
SLD600	F2	648	720	1,302
SLD800	F2	1,091	1,212	1,844
SLB362	F1	364	405	661
	F2	2,563	2,848	4,381
SLB600	F1	364	405	661
	F2	2,509	2,788	4,245
SLB600-HD, (2) ¼” Screws	F1	374	416	679
	F2	1,901	2,112	3,216

Connector	Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
SLB600-HD, (1) ½” Anchor	F1	388	431	704
	F2	1,606	1,785	2,718
SLB800	F1	357	397	604
	F2	2,563	2,848	4,381
SLB1000	F2	2,266	2,517	4,112
SLB1200	F2	2,266	2,517	4,112
SLBxxx-10, -12	F2	2,266	2,517	4,112
SLS362/400-9, -12	F2	1,991	2,096	3,821
SLS600-12	F2	3,315	3,489	5,237
SLS600-15, -18, -20	F2	3,398	3,577	5,750
SLS600-24	F2	3,036	3,196	5,137
SLS800-12, -15, -18, -20	F2	2,909	3,062	4,922
SLT9.5	F1	546	575	991
	F2	822	865	1,492
SLT(L)	F1	784	825	1,422
	F2	1,116	1,175	2,026
Splice600	F2	2,282	2,402	3,861
	F3	3,888	4,092	6,578
Splice800	F2	2,282	2,402	3,861
	F3	3,639	4,044	6,158

Notes:

Strength values provided are those of the clip only (One clip). Attachment to stud framing and to structure must be evaluated independently.
Nominal Strength is calculated as LRFD Strength divided by an average resistance factor of 0.9.
Ultimate Strength is the average maximum load obtained from tests.
When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).

DriftClip® and DriftTrak® Series

Connector	Load Direction	Fastener Pattern	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
DSLB362, 600, 800	F2	1	1,467	1,630	2,317
		2	916	1,018	1,663
DSLS600-12	F2	1	2,980	3,311	4,707
		2	2,788	3,098	4,405
DSLS600-15	F2	1	3,045	3,383	4,811
DSLS600-15[1]	F2	2	3,045	3,383	5,008
DSLD362	F2	1	186	207	317
		2	85	94	141
DSLD600	F2	1	286	317	481
		2	399	443	869
DSLD800	F2	1	318	354	578
		2	293	326	858
DSL362	F2	1	796	884	1320
		2	397	441	720

Connector	Load Direction	Fastener Pattern	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
DSL600	F2	1	1,242	1,380	2,254
		2	1,840	2,044	3,051
DSL800	F2	1	1,666	1,851	3,023
DSL800[1]	F2	2	1,666	1,851	4,122
DTSL	F2	8" Fastener Spacing - Pattern 1	1,001	1,112	1,807
		8" Fastener Spacing - Pattern 2	770	856	1,303
		16" Fastener Spacing - Pattern 1	1,338	1,487	2,264
		16" Fastener Spacing - Pattern 2	774	860	1,309
DTSLB362, 600, 800	F2	8" Fastener Spacing - Pattern 1 and 2	1,292	1,435	2,186
		16" Fastener Spacing - Pattern 1 and 2	1,206	1,340	2,040
DTSLB-HD 362, 600, 800	F2	8" Fastener Spacing - Pattern 1 and 2	2,591	2,879	4,384
		16" Fastener Spacing - Pattern 1 and 2	1,640	1,822	2,775
DTLB600	F2	8" Fastener Spacing	1,292	1,435	2,186
	F3		2,434	2,704	4,118
DTLB800	F2	8" Fastener Spacing	1,292	1,435	2,186
	F3		2,434	2,704	4,118

Notes:

[1]LRFD strength limited by fastener pattern 1.
Strength values provided are those of the clip only (One clip). Attachment to stud framing and to structure must be evaluated independently.
Nominal Strength is calculated as the LRFD Strength divided by an average resistance factor of 0.9.
Ultimate Strength is maximum load obtained from tests.
When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).

StiffClip® Series

Connector	Load Direction	LRFD Design Strength (lbs or in-lbs)	Nominal Strength (lbs or in-lbs)	Ultimate Strength (lbs or in-lbs)
AL362	F1	1,177	1,308	2,137
	F2	2,493	2,770	4,219
	F3	4,522	5,025	7,652
AL600	F1	1,388	1,542	2,348
	F2	3,493	3,882	5,911
	F3	4,830	5,366	8,172
AL800	F1	2,827	3,141	4,784
	F2	4,022	4,469	6,806
	F3	9,798	10,887	16,579
LB362	F1	1,481	1,646	2,506
	F2	3,297	3,664	5,579
	F3	4,256	4,729	7,202
LB600	F1	1,481	1,646	2,506
	F2	3,297	3,664	5,579
	F3	2,869	3,188	4,855

Connector	Load Direction	LRFD Design Strength	Nominal Strength	Ultimate Strength
		(lbs or in-lbs)	(lbs or in-lbs)	(lbs or in-lbs)
LB600-HD, (2) ¼" Screws	F1	1,764	1,959	2,984
	F2	1,810	2,011	3,062
	F3	3,149	3,499	5,328
LB800	F1	1,993	2,214	3,617
	F2	3,297	3,664	5,579
	F3	6,188	6,875	10,470
LB800-4" Offset	F1	1,993	2,214	3,617
	F2	3,297	3,664	5,579
	F3	2,496	2,773	4,223
LB1000	F1	1,465	1,627	2,658
	F2	2,270	2,522	4,120
	F3	2,872	3,191	4,859
LB1000-4" Offset	F2	2,270	2,522	4,120
	F3	2,506	2,784	4,240
LB1200	F1	1,465	1,627	2,658
	F2	2,270	2,522	4,120
	F3	3,041	3,379	5,146
HE(L)-43 mil	F2	1,003	1,114	1,696
	F3	4,901	5,446	8,293
HE(H)-68 mil	F2	1,739	1,932	2,943
	F3	8,880	9,867	15,026
HE(S)-68 mil	F2	1,739	1,932	2,943
	F3	4,753	5,281	8,043
HS362	F2*	4,420	8,840	11,492
	F3	1,773	1,970	3,000
HS600	F2*	6,630	13,260	17,238
	F3	2,943	3,270	4,980
HS800	F2*	6,630	13,260	17,238
	F3	3,885	4,317	6,574
CL362/400-68	F1	2,267	2,519	4,122
	F2	3,071	3,412	4,851
	F3	1,842	2,047	3,349
	M1 (in-lbs)	2,888	3,209	5,251
CL362/400-118	F1	3,880	4,311	6,129
	F2	7,090	7,878	11,201
	F3	3,611	4,012	6,565
	M1 (in-lbs)	6,299	6,999	11,453
CL362/400-118H	F1	4,160	4,622	6,572
	F2	7,973	8,858	12,595
	F3	9,150	10,167	14,455
	M1 (in-lbs)	10,750	11,944	19,545
CL600-68	F1	2,275	2,528	3,594
	F2	4,020	4,467	6,351
	F3	1,932	2,147	3,513
	M1 (in-lbs)	4,978	5,531	9,050

Connector	Load Direction	LRFD Design Strength (lbs or in-lbs)	Nominal Strength (lbs or in-lbs)	Ultimate Strength (lbs or in-lbs)
CL600-118	F1	4,131	4,590	7,147
	F2	6,578	7,308	10,391
	F3	3,561	3,956	6,474
	M1 (in-lbs)	9,126	10,140	16,592
CL600-118H	F1	6,659	7,399	10,520
	F2	10,337	11,485	16,330
	F3	9,620	10,689	15,197
	M1 (in-lbs)	9,958	11,065	18,106
CL800-68	F1	2,298	2,553	3,630
	F2	4,263	4,736	6,734
	F3	1,724	1,916	3,135
	M1 (in-lbs)	4,578	5,086	8,323
CL800-118	F1	5,375	5,972	8,491
	F2	10,265	11,406	16,217
	F3	4,270	4,744	8,291
	M1 (in-lbs)	13,170	14,634	23,946
CL800-118H	F1	7,713	8,570	12,185
	F2	13,251	14,723	20,933
	F3	11,925	13,250	18,839
	M1 (in-lbs)	17,834	19,815	32,425
TD	F3	15,722	17,469	19,127

Notes:

Strength values provided are those of the clip only (One clip). Attachment to stud framing and to structure must be evaluated independently.
Nominal Strength is calculated as LRFD Strength divided by an average resistance factor of 0.9.
Ultimate Strength is the average maximum load obtained from tests.
When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).
Clip connectors or load directions marked with an (*) have their LRFD, nominal, and ultimate strength values all calculated using AISI S100-12 provisions.

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